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Project/Task	Pit 9 Comprehensive Demonstration		
Subtask	Summary Process Descriptions	EDF Page 1	of 11

TITLE: Summary Process Description of Proposed Remedial Alternatives for a Cleanup of Pit 9 at the INEL Radioactive Waste Management Complex

SUMMARY

The summary briefly defines the problem or activity to be addressed in the EDF, gives a summary of the activities performed in addressing the problem and states the conclusions, recommendations, or results arrived at from this task.

The purpose of this Engineering Design File (EDF) is to provide a summary process description for the Pit 9 Administrative Record of the preferred remedial alternatives identified in the Revised Proposed Plan for a Cleanup of Pit 9 at the Radioactive Waste Management Complex and briefly evaluate the technical performance of the preferred technology against the other remedial process options.

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Summary Process Description of Proposed Remedial Alternatives for a Cleanup of Pit 9 at the INEL Radioactive Waste Management Complex

INTRODUCTION

The purpose of this engineering design file (EDF) is to provide a more detailed description of Alternative 4, identified as the preferred remedial alternative in the **Revised Proposed Plan for a Cleanup of Pit 9 at the Radioactive Waste Management Complex, Idaho National Engineering Laboratory**, and to briefly evaluate the technical performance of the preferred alternative against the other remedial alternatives listed in the proposed plan.

The Environmental Protection Agency, the Idaho Department of Health and Welfare, and the Department of Energy (hereafter referred to as the agencies) have designated Pit 9 as operable unit 7-10 in Waste Area Group (WAG) 7 in the Idaho National Engineering Laboratory (INEL) Federal Facility Agreement/Consent Order. After conducting a screening of the existing remedial technologies which could be used to clean up a mixed waste site such as Pit 9, the Agencies determined a combination of technologies consisting of physical separation, chemical extraction and stabilization processes would result in the best overall protection of human health and the environment at Pit 9. In the revised proposed plan, this combination of technologies is described under Alternative 4, the preferred alternative.

Five alternatives are evaluated in the revised proposed plan: Alternative 1 - No Action, Alternative 2 - In-Situ Vitrification, Alternative 3 - Ex-Situ Vitrification, Alternative 4 - Physical Separation/Chemical Extraction/Stabilization Process, and Alternative 5 - Complete Removal, Storage, and Off-Site Disposal.

Background

Pit 9 is located in the northeast corner of the Subsurface Disposal Area (SDA) at the RWMC. Waste was placed in Pit 9 at the SDA from November 1967 to June 1969. It presently has an overburden that averages about 6 ft thick. There is approximately 250,000 ft^3 of overburden, 150,000 ft^3 of packaged waste, and 350,000 ft^3 of soil between and below the buried waste at the time of Pit 9 closure. The depth of the pit from ground surface to bedrock is approximately 17.5 ft and the horizontal dimensions are approximately 127 ft by 379 ft.

The inventory of wastes buried within Pit 9 was estimated from available shipping records and the Radioactive Waste Management Information System (RWMIS). The waste within Pit 9 is primarily transuranic waste generated at the Rocky Flats Plant and additional wastes (primarily low-level waste) from waste generators located at the INEL. Approximately 110,000 ft^3 of waste buried in Pit 9 was generated at the Rocky Flats Plant, and consisted of drums of sludge (contaminated with a mixture of transuranic and organic solvents), drums of assorted solid waste, and cardboard boxes containing empty contaminated drums. There were approximately 4,000 drums; 2,500 boxes (approximately 1,500 contained empty contaminated drums); and 80 unspecified containers of waste buried within Pit 9. In general, the boxes were disposed at the north end of the pit, and the drums were dumped in the south end, although intermixing of containers in the pit did occur due to flooding in 1969.

Overall Cleanup Scope
The Pit 9 remedial action would consist of the following three phases should the preferred alternative be implemented: a proof-of-process (POP), a limited production test (LPT), and final remediation. The test phases would be performed within the interim action for Pit 9 prior to full-scale remediation to confirm treatment standards can be met and identify the most cost effective technique, or combination of techniques, that will be utilized in the remedial design. The POP phase would require extensive demonstration of critical aspects of the process to prove that innovative technology from the proposed processes would be effective in the protection of worker and public health and safety, and in the remediation of Pit 9.

The data generated in the POP test would be used to identify the remedial process that performs best on the Pit 9 waste types. The POP phase would test critical aspects of the processes to prove that they would be effective in treating the americium and plutonium, as well as other hazardous constituents located within Pit 9. In general, the POP test would be used to evaluate the following aspects of the processes under consideration:

- the ability of the chemical separation process(s) to perform as an integrated system at pilot or engineering scale for a minimum of 100 hours of unit operation on the schedule which would be used for actual Pit 9 remediation.

- the thermal stabilization system and associated off-gas exhaust system for the ability to operate a minimum of 100 hours on the schedule which would be used for actual Pit 9 remediation using a minimum feed rate of 300 to 500 lbs/hr.

The LPT phase would demonstrate that all integrated systems function as proposed to give a high degree of confidence that all systems are reliable before full-scale remediation would begin. The LPT phase would involve the same processes, area, and impacts as the remediation phase, but on a smaller test scale. If the goals of the limited production test are not met, the remedy would not be used on Pit 9.

DESCRIPTION OF THE PREFERRED TECHNOLOGIES
In November 1991 a request for proposals was released to industry to obtain subcontractor proposals for a cleanup of Pit 9. In response to the request, two suitable subcontractor proposals were received. The two proposals consisted of unique combinations of chemical extraction, physical separation, and stabilization technologies. In the revised proposed plan, the description of Alternative 4 consists of a combination of the chemical extraction, physical separation, and stabilization technologies included in the two subcontractor proposals. Due to the way these processes are described in the proposed plan, their similarities and differences may not be obvious. In this EDF the two processes are described separately so they can be more easily

compared. The following section consists of detailed summaries of the two remedial processes that were described in the revised proposed plan as Alternative 4.

Alternative 4 - Subcontractor #1 Process

Retrieval/Segregation System
Under this approach, hazardous substances would be retrieved in a fixed, concrete, double-contained structure under negative pressure which is built over the entire Pit at the start of the project. The pit would be worked using remotely operated excavating equipment which is enclosed in a curtained area to separate the excavation area from the rest of the pit. The curtain area ventilation enclosure would confine contaminated dust and the buildup of volatile organic contaminants at the dig site. The excavator (and associated manipulating equipment) would perform an initial segregation of waste materials in the pit into the following five waste streams: combustibles (paper, plastics, and rags), wood, drums and metals, soil and sludge, and non-soils and large items. This initial segregation would simplify the overall material handling and processing systems downstream.

A dig face radiation monitor would be used to make a gross radioactivity level assessment of the waste at the dig face during excavation activities. The radiation monitor would have sufficient mobility to allow placement within a few inches of any area of the dig face. The readings would determine how the material would be handled as it is excavated. In the event that readings are high, the material would be mixed with scoops of lower reading material. In this way, the overall treatability of the material would be enhanced.

Following initial segregation, wastes are placed in specialized, color-coded tram containers which then enter the waste transport system which includes a conveyer system for transporting the trams to the material handling facility from the dig site. Additional retrieval system process equipment include a compactor to compact drums, a specialized grapple to pick up drums and drum remnants, and teleoperated manipulators to provide waste handling and segregation tasks in the pit such as cutting and drilling.

Once wastes arrive in the material handling facility they are segregated (using remotely controlled equipment) into separate waste streams at multiple handling stations. Operations performed include:

- Segregation of the waste for processing or storage
- Size-segregation of the soil and sludge wastes (to less than 2 inches) for processing in the treatment system described below
- Delivery of treatable soils to the processing facility for treatment
- Compaction of appropriate waste to minimize volume
- Shredding and sizing of large items and combustibles (including wood, metals, rags, paper and plastic) prior to decontamination in a specialized washing process

Materials contaminated with polychlorinated biphenyls (PCBs) will be segregated and accumulated until a sufficient volume is collected to permit cost effective treatment. The PCBs will then be destroyed in a proprietary dechlorination process which chemically converts the PCBs to a non-hazardous form.

Treatment System
Waste materials which are less than 2 inches in size (including contaminated soil, sludge, and non-soil wastes) would be sent to the treatment system for processing. The proposed treatment involves three principal subsystems. The extraction subsystem includes a proprietary carbonate/EDTA chemical leach system for removal of actinides (plutonium and americium) and heavy metals from the soil. Dissolution effectiveness is affected by soil size, feed makeup and contact time. This subsystem also includes a surfactant-enhanced soil wash system for organics removal. The primary function of the extraction susbsystem would be to move the contaminants from a solid to aqueous phase.

Extraction system overflows and slurries are routed to the filtration subsystem consisting of a clarifier, filter tank and filter press. Clarifier sludges are sent to the filter tank for preparation before entering the filter press. After processing in the filter press, the solids would be separated from the liquids and a high solids (60% or greater) filter cake would be produced. Near the end of the filtration cycle cleaned process water is used for a final wash of the pressed cake prior to discharge. The dried solids from the filter press should meet clean-up standards of less than 10 nanocuries per gram (nCi/g) transuranics (TRU), if not they will be recycled for additional extraction. The filtrate from the filter press is returned to the extraction subsystem.

Clarifier overflow, which should contain plutonium, americium, heavy metals and organics, is sent to a final proprietary subsystem consisting of an evaporator, a catalytic oxidizer and a scrubber/condenser. The evaporator concentrates and volume reduces the process water (from the clarifier feed) into a volatilized and non-volatilized fraction. The organics in the volatilized fraction would be destructively oxidized resulting in a "pure" water stream which could be reused in the process, or eventually discharged along with some CO_2 gas. Off-gases from the oxidizer are wet scrubbed. The non-volatilized fraction, referred to as "waste product", contains non-volatile organics, concentrated salts, heavy metals and radionuclides. The waste product would contain a solids fraction around 65% depending on the nature of the feed. If necessary, the waste product would undergo a stabilization process prior to packaging in drums for TRU storage. The waste product would meet the Radioactive Waste Management Complex waste acceptance criteria, or, in the event that the hazardous waste materials are present, the waste product would meet land disposal restriction (LDR) requirements. Figure 1, on the following page, is the simplified process flow diagram for this approach.

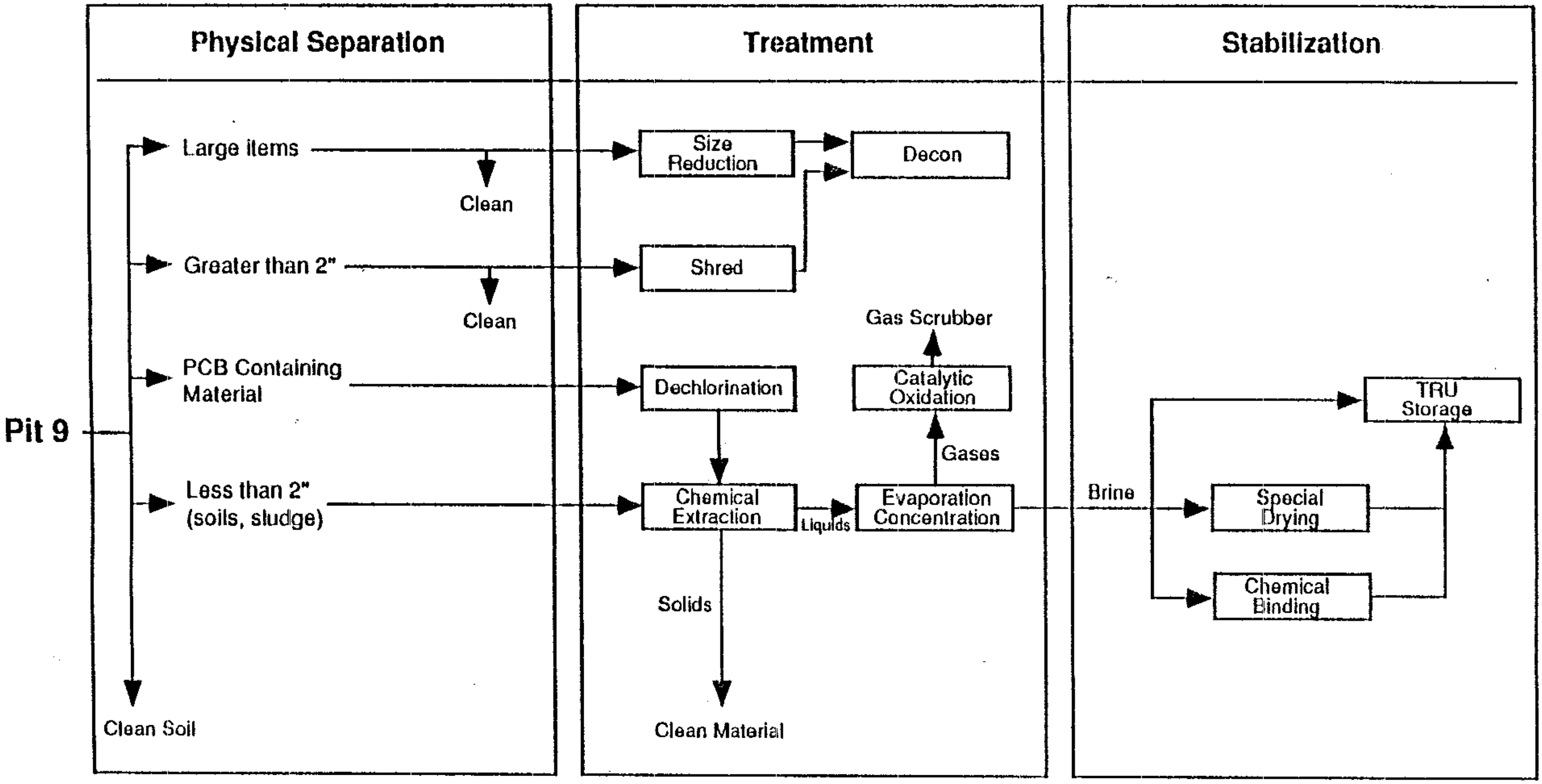

Figure 1. Approach One Simplified Process Diagram.

Alternative 4 - Subcontractor #2 Process

Retrieval/Segregation System
Under this remedial process, retrieval would be performed inside a movable, redundant containment structure with a flexible skirt and a remote teleoperated bridge crane system to prevent dispersion of contaminants into the environment and to protect operators/workers from exposure to radiation, hazardous substances and other hazards associated with excavating the pit. Separated materials would be transported from the pit to the processing building via an enclosed track in sealed containers on wheeled carts.

Inside the process building the containers are stockpiled awaiting processing in an area served by a bridge crane for handling. Contaminated soil would be separated from non-soil wastes and inventory tracking would be maintained using codes on the containers which identify the content of fissile material and all special handling requirements.

Treatment System
Soil processing would begin with removal of volatile organic compounds (VOCs) using a low temperature solvent extraction with triethylamine (TEA). This is followed by gravimetric and physical removal of particulate plutonium and americium from the coarse soil fraction. The fine fraction which exits the gravimetric system in the tailings would be leached with nitric acid to dissolve the contained plutonium and other hazardous materials. The metal nitrates in the resultant solution would be removed using a counter current ion exchange system.

The "clean" soil would be transferred from the leach circuit after dewatering to a rotary kiln to remove residual nitrates. Nitrate bearing liquid process wastes would be treated by electrodialysis for recovery of nitric acid, sodium hydroxide and cleaned water. These materials would be returned to the process. The concentrated residues from this system would be transferred to the plasma melter for stabilization as a cast slag. After denitrification the soil would be sampled, stockpiled until analysis verifies clean up criteria are met, and then redeposited in the pit. Figure 2, on the following page, depicts the simplified process flow for this approach.

The non-soil wastes and the residual concentrates from the soil treatment system would be sent directly to the plasma melter which would destroy the organics and produce a virtually non-leachable cast slag that immobilizes both the heavy metals and transuranics. To prevent the possibility of plutonium release with the process off-gases, the melter would be equipped with an emissions control system that employs high temperature cross flow sintered metal or ceramic filters to capture plutonium particles after condensation, scrubbers to abate acid gases, and HEPA filters. All of the plant emissions would meet the requirements of the Clean Air Act. A final radioactive/non radioactive sort would then be made on the plasma furnace slag to determine whether to return it to Pit 9 or to store it as a transuranic waste.

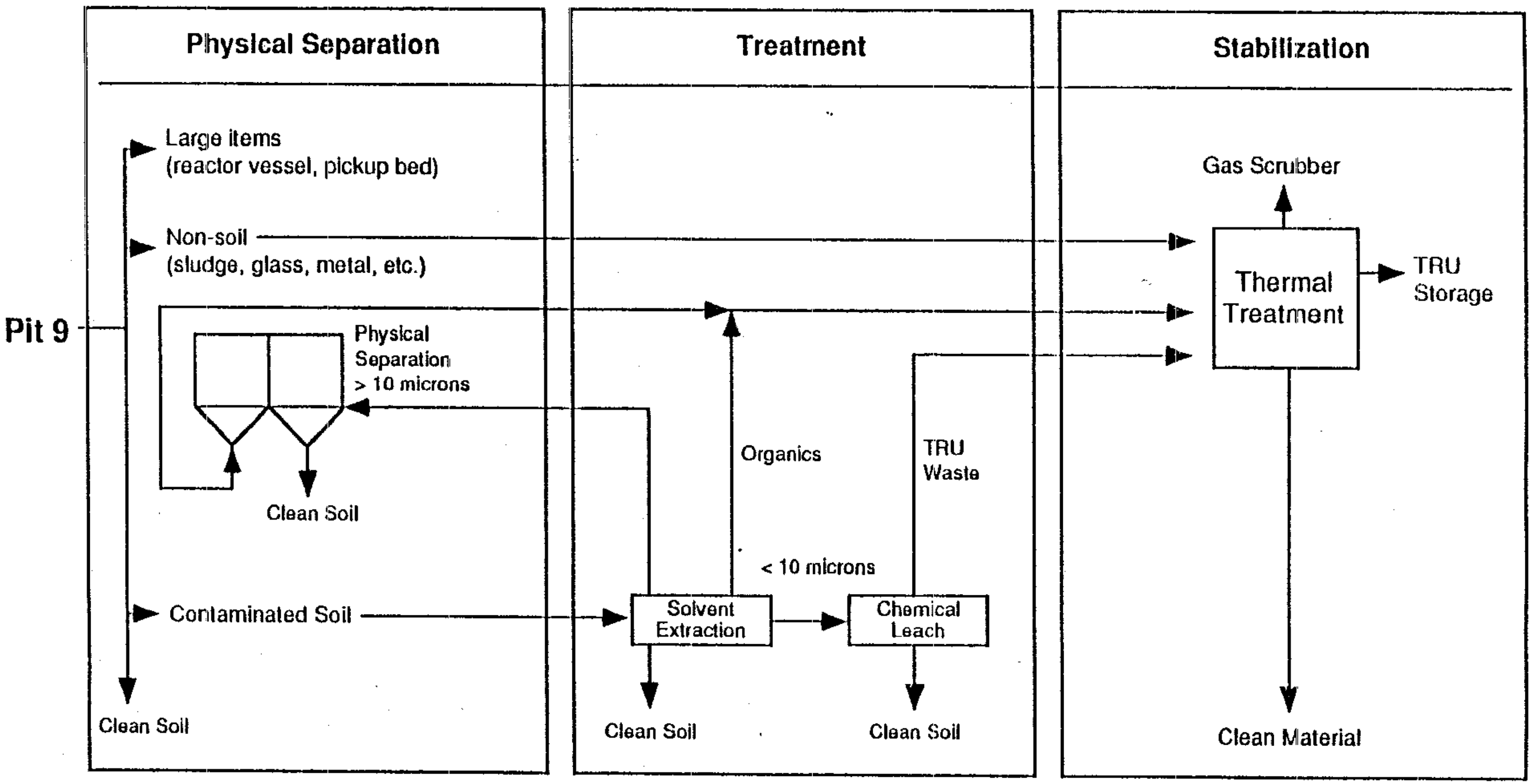

Figure 2. Approach Two Simplified Process Diagram.

TREATMENT STANDARDS

The criteria for residuals returned to Pit 9, or for waste to be left in place in the pit, would reduce concentration of contaminants based on the following performance criteria (as appropriate): 1) a current industrial scenario of $\leq 10^{-4}$ for carcinogenic risk or <1 hazard index for noncarcinogenic health effects; or 2) meets LDR requirements.
Treatment standards for the contaminants in Pit 9 would be: 1) average concentrations of transuranic isotopes in residuals (i.e., treated waste streams) being returned to Pit 9 would be <10 nCi/g; and 2) wastes and/or materials in Pit 9 containing > 10 nCi/g transuranics would be treated to reduce the volume by >90% (in addition to meeting the treatment standard in 1 above) prior to returning to the pit; and 3) for materials being treated and returned to Pit 9, all applicable ARARs (including LDRs) would be met.

In summary, many of the processes described have been demonstrated in field operations, some of which have been used to remediate similar radiologically-contaminated sites; therefore, it is expected that the treatment standards described above would be attainable should a chemical extraction/physical separation/stabilization process be employed to clean up Pit 9. Following remediation activities, contaminated soils that are treated to remove TRU and other contamination will be returned to Pit 9 and the pit backfilled to above grade and sloped to encourage drainage away from the pit.

EVALUATION OF ALTERNATIVES

In addition to Alternative 4 described above, the Agencies also evaluated the following technologies to perform the Pit 9 cleanup: in-situ vitrification (Alternative 2), ex-situ vitrification (Alternative 3), and complete removal, storage, and off-site disposal (Alternative 5). Each of the technologies was evaluated against performance criteria in order to identify the remedial process which would provide the highest degree of technical performance if implemented for Pit 9 cleanup. The agencies determined that Alternative 4 would provide the best balance of trade-offs among the alternatives listed above.

All of the technologies identified, either through treatment or removal of contaminants, would eliminate the potential for migration of contaminants thereby reducing the risk of exposure to the public and the environment. At present, uncertainty exists regarding the long term effectiveness of Alternative 2 and there are currently no off-site disposal facilities available for treatment residuals or wastes that would be generated from Alternatives 3, 4, and 5. In addition, all of the processes would be designed to meet applicable or relevant and appropriate requirements of federal and state environmental laws.

Long-term Effectiveness and Permanence
The physical separation and chemical extraction processes involved in the preferred technology provide a significant reduction in the waste prior to stabilization; therefore, Alternative 4 would result in a smaller volume of residuals requiring long-term monitoring than Alternatives 3 and 5. The long-term protectiveness and permanence of Alternative 2 is not well defined at

this time (see discussion under implementability below). Alternative 5 would not reduce the amount of contamination and would require extensive long-term management and monitoring of the stored waste. In addition, there is a high degree of uncertainty associated with the availability of an off-site disposal facility that would be able to accept untreated mixed waste.

Reduction of Toxicity, Mobility, or Volume through Treatment
Alternatives 2, 3, and 4 utilize treatment processes that achieve a reduction in the toxicity, mobility and volume of the contaminants in Pit 9. The preferred technology adds physical/chemical treatment to the stabilization treatment and, therefore, achieves a greater reduction in waste volume and toxicity prior to stabilization of the reduced waste stream. Alternative 4 also results in a smaller volume of treatment residuals. The vitrification technologies reduce toxicity, mobility, and volume but to a lesser degree than the preferred remedial process. The removal approach does not treat the principal threats and does not reduce the toxicity, mobility, or volume of the waste through treatment.

Short-term Effectiveness
Each of the alternatives would be implemented using available engineering controls to protect workers and the public during implementation of the remedy. Alternative 2 does not require excavation of the waste material but would require significant additional study prior to full-scale remediation and an increased time until response objectives are achieved. Both Alternatives 3 and 4 require excavation and handling of the waste but require less study and development prior to full-scale remediation.

Implementability
As mentioned above, Alternative 4 involves the use of processes that have been demonstrated in field operations, some of which have been used to remediate similar radiologically-contaminated sites. As mentioned in the process description section above, the use of the physical segregation and chemical separation phases of the preferred remedial process increases the efficiency of stabilization on the refined, well-characterized waste stream and also reduces the volume of material requiring treatment. Ex-situ vitrification and the preferred process both require additional treatability testing but do not require the extensive technology development that would be needed to implement in-situ vitrification on the types of waste materials found in Pit 9. An off-site disposal facility is currently not available to accept the untreated mixed waste that would result from removal of the wastes without treatment.

In-situ vitrification is not well defined at this time due to uncertainties associated with the process efficiency and difficulty in evaluating the effectiveness of in-situ vitrification on the heterogeneous wastes found in Pit 9. Additional uncertainties exist regarding the ability to confirm complete vitrification/stabilization of the pit contents. Some of the specific difficulties with in-situ vitrification are: 1) Gases generated from combustible materials (i.e. wood, cardboard, combustible organic liquids) may carry contaminants to the glass surface and away from the melt with the potential for overwhelming the off-gas system; 2) Metals such as mercury or cadmium may be undesirable because of their difficulty to incorporate into the melt, or their reduction of product quality; 3) There exists a potential for contaminants to migrate into the surrounding soil preceding the melt during vitrification; and 4) There exists a possibility for shorting between the electrodes due to the presence of metals in the feed material (resulting in incomplete vitrification). Most of the present difficulties in implementing in-situ vitrification on Pit 9 waste materials can be overcome by pre-treatment and segregation activities such as those conducted in the preferred remedial process.